CLAIMS:

1. An active balance system for reducing vibrations of an axially reciprocating machine, comprising:

a support member configured for attachment to the machine;

a flexure assembly including at least one spring having connections along a central portion and an outer peripheral portion, one of the central portion and the outer peripheral portion fixedly mounted to the support member;

a counterbalance mass fixedly carried by the flexure assembly along another of the central portion and the outer peripheral portion; and

a linear motor having one of a stator and a mover fixedly mounted to the support member and another of the stator and the mover fixedly mounted to the counterbalance mass, and operative to axially reciprocate the counterbalance mass.

2. The active balance system of claim 1 wherein the flexure assembly comprises a pair of flexure assemblies spaced apart from one another.

3. The active balance system of claim 2 further comprising a shaft carried by the pair of flexure assemblies along respective central portions, wherein the counterbalance mass is carried by the shaft.

4. The active balance system of claim 3 wherein the counterbalance mass comprises a pair of masses each carried along opposite ends of the shaft.

5. The active balance system of claim 1 wherein the mass comprises at least one concentrated mass affixed to the mover.

6. The active balance system of claim 1 wherein the support member is configured for attachment with a housing of a Stirling generator, and wherein the counterbalance mass is oriented for reciprocation along an axis parallel to an axially reciprocating member within the generator.

7. The active balance system of claim 1 wherein the linear motor comprises a linear electrodynamic machine having a stator assembly including the stator and magnets and a mover assembly including the mover and ferromagnetic laminations, wherein a flux gap is provided between the ferromagnetic laminations and the magnets.

8. The active balance system of claim 1 wherein the support member comprises a tubular support housing affixed to the machine.

9. The active balance system of claim 1 further comprising a controller configured to electrically connect together the linear motor and an alternator of the machine.

10. A vibration balanced machine, comprising:

a housing member carrying a working member in substantially axial oscillating relation within the machine;

a support member configured for attachment to the housing member;

a flexure assembly including at least one flat spring having connections along a central portion and an outer peripheral portion, one of the central portion and the outer peripheral portion fixedly mounted to the support member;

a counterbalance mass fixedly carried by the flexure assembly along another of the central portion and the outer peripheral portion; and

a linear motor having one of a stator and a mover fixedly mounted to the support member and another of the stator and the mover fixedly mounted to the counterbalance mass, and operative to axially reciprocate the counterbalance mass so as to counterbalance at least in part vibration forces generated by movement of the working member within the housing member.

11. The vibration balanced machine of claim 10 further comprising an active vibration control system and a vibration force detector associated with the housing member and coupled with the active vibration control system, wherein the active vibration control system receives a signal indicative of detected vibration forces of the machine, and, in response to the signal, the active vibration control system regulates operation of the linear motor to oscillate the counterbalance mass so as to substantially counterbalance the detected vibration forces.

12. The vibration balanced machine of claim 11 wherein the signal comprises a first harmonic vibration frequency, and the linear motor is driven at a fundamental vibration frequency, substantially 180 degrees out of phase with the signal.

13. The vibration balanced machine of claim 11 wherein the active vibration control system comprises control circuitry and memory.

14. The vibration balanced machine of claim 13 wherein the control circuitry comprises processing circuitry, and further comprising an analog-to-digital (A/D) converter operative to convert between analog and digital signals.

15. The vibration balanced machine of claim 14 wherein the vibration force detector generates an analog output signal, and wherein the A/D converter converts the analog output signal to a digital signal for processing by the processing circuitry.

16. The vibration balanced machine of claim 15 further comprising a digital-to-analog (D/A) converter operative to convert between digital and analog signals, wherein the processing circuitry generates a digital output signal that approximates and substantially opposes the detected vibration force signal, and wherein the D/A converter converts the digital output signal to a corresponding analog output signal that drives the linear motor.

17. The vibration balanced machine of claim 11 wherein the vibration control system comprises a fast Fourier transform (FFT) analyzer.

18. The vibration balanced machine of claim 16 wherein the processing circuitry implements a modified Newton's method to calculate amplitude and phase for the digital output signal.

19. An active vibration control system for an axially reciprocating machine, comprising:

a housing;

a linear alternator having a stator rigidly carried by the housing and a mover supported for axially reciprocating movement;

a counterbalance mass provided for axially reciprocating movement along an axis substantially coaxial with a motion axis of the mover of the linear alternator;

a linear actuator communicating with the mass, carried by the housing, and configured to move the counterbalance mass relative to the alternator at a substantially common frequency; and

analog control circuitry communicating with the linear actuator and user adjustable to adjust displacement amplitude of the linear actuator relative to the mover of the linear alternator.

20. The control system of claim 19 wherein the analog control circuitry comprises voltage divider circuitry.

21. The control system of claim 20 wherein the voltage divider circuitry comprises a variable resistor and a tuning capacitor.

22. The control system of claim 20 wherein the linear alternator and the linear actuator operate at different operating voltages, and the voltage divider circuitry couples together the linear alternator and the linear actuator so as to accommodate the respective different operating voltages.

23. The control system of claim 19 wherein the analog control circuitry comprises decoupling circuitry.

24. The control system of claim 23 wherein the decoupling circuitry comprises a variable transformer and a tuning capacitor, wherein the variable transformer electromagnetically couples together the linear alternator and the linear actuator.

25. The control system of claim 19 further comprising a fast Fourier transform (FFT) analyzer configured to detect vibration frequencies of the axially reciprocating machine, wherein the analog control circuitry cooperates with the FFT analyzer to adjustably control the linear actuator and reduce the detected vibration frequencies.

26. The control system of claim 19 further comprising a vibration force detector coupled with the housing and operative to generate a vibration force generated by the axially reciprocating machine.

27. A vibration control system for linear reciprocating machines, comprising:

a first axially reciprocating machine;

a second axially reciprocating machine rigidly mounted in aligned relation with the first axially reciprocating machine, electrically coupled with the first axially reciprocating machine, and operated in synchronized, opposed directions relative to the first axially reciprocating machine;

first tuning circuitry associated with the first axially reciprocating machine; and

second tuning circuitry associated with the second axially reciprocating machine;

wherein one of power to at least one of the machines and a tuning factor for at least one of the first tuning circuitry and the second tuning circuitry is adjusted to minimize vibration for the linear reciprocating machines.

28. The control system of claim 27 wherein the first tuning circuitry comprises a first tuning capacitor and the second tuning circuitry comprises a second tuning capacitor, and wherein the tuning factor comprises a capacitance value for at least one of the first tuning capacitor and the second tuning capacitor.

29. The control system of claim 28 further comprising a vibration force detector and a vibration controller, wherein the vibration controller receives a signal indicative of detected vibration forces of the system, and, in response to the signal, the controller regulates at least one of operation of at least one of the machines and a capacitance value of at least one of the tuning capacitors so as to substantially reduce the detected vibration forces.

30. The control system of claim 29 wherein the controller adjusts power generated by one of the reciprocating machines.

31. The control system of claim 29 wherein the controller adjusts capacitance value for one of the first capacitor and the second capacitor.

32. The control system of claim 29 wherein power to the reciprocating machines and capacitance values for the tuning capacitors are adjusted so as to substantially reduce detected vibration forces for a primary mode vibration frequency, and further comprising a linear alternator and a counterbalance mass, the linear alternator having a stator rigidly carried by at least one of the machines and a mover supported for axial reciprocating movement, the counterbalance mass carried by the mover for axially reciprocating movement along an axis parallel with a motion axis of the mover.

33. The control system of claim 32 wherein the counterbalance mass comprises at least one balance mass disposed such that a net effective balance mass is coaxial with an axis of reciprocation of the generator.

34. The control system of claim 32 wherein the control system controllably regulates operation of the linear alternator to move the counterbalance mass so as to reduce vibration at a secondary mode of the vibration frequency.

35. The control system of claim 28 wherein the first tuning circuitry and the second tuning circuitry comprises a digital signal processor configured to implement power factor correction circuitry that implements digital tuning by changing current phase angle and relationship relative to voltage so as to realize a power factor of unity.

36. A method for controlling vibration from axially reciprocating machines, comprising:

providing a first axially reciprocating machine with an associated first tuning circuitry and a second axially reciprocating machine with a second tuning circuitry, wherein the first machine and the second machine are rigidly mounted together in axially aligned relation;

AC coupling the first axially reciprocating machine with the second axially reciprocating machine;

operating the first machine and the second machine in synchronized, opposed directions; and

adjusting power to at least one of the machines or adjusting a tuning value for at least one of the first tuning circuitry and the second tuning circuitry to minimize vibration for the axially reciprocating machines.

37. The method of claim 36 wherein the first tuning circuitry comprises a first tuning capacitor and the second tuning circuitry comprises a second tuning capacitor, wherein the tuning value for each of the first tuning capacitor and the second tuning capacitor each comprises a capacitance value.

38. The method of claim 37 further comprising controllably regulating a capacitance value for at least one of the tuning capacitors to decrease vibration forces.

39. The method of claim 37 further comprising controllably regulating power delivery to at least one of the machines to minimize vibration forces.